L. Superior

BEVL

STANDARDS DEVELOPMENT BRANCH OMOE
36936000009216

REPORT OF WATER QUALITY IN HAZELWOOD LAKE DISTRICT OF THUNDER BAY

1973

Ministry of the Environment
Ontario

The Honourable
William G. Newman,
Minister

Everett Biggs,
Deputy Minister

Copyright Provisions and Restrictions on Copying:

This Ontario Ministry of the Environment work is protected by Crown copyright (unless otherwise indicated), which is held by the Queen's Printer for Ontario. It may be reproduced for non-commercial purposes if credit is given and Crown copyright is acknowledged.

It may not be reproduced, in all or in part, for any commercial purpose except under a licence from the Queen's Printer for Ontario.

For information on reproducing Government of Ontario works, please contact ServiceOntario Publications at copyright@ontario.ca

REPORT

OF

WATER QUALITY

IN

HAZELWOOD LAKE

DISTRICT OF

THUNDER BAY

1973

GENERAL TABLE OF CONTENTS

LIST OF FIGURES

PREFACE

The Province of Ontario contains many thousands of beautiful small inland lakes which are most attractive for recreational use. Lakes close to urban areas and accessible by road often receive heavy use in terms of cottage development, camp sites, trailer parks and picnic areas.

A heavy influx of people may subject a lake and its surrounding environment to great stress. In some cases, developments are carried out on attractive lakes only to find that when this is complete the lake qualities which were initially so appealing have been damaged. The appearance of the shoreline can be marred by construction, fishing ruined by over-harvesting or by the growth and decay of excessive amounts of algae and weeds. Motor boats introduce noise and petroleum pollution. Inadequate disposal of human wastes can place a great stress on the lake environment.

The accepted custom of having "a place at the lake" continues to apply pressure for more development, giving rise to an even greater expansion of problems.

The Ontario Ministry of the Environment is attempting to bring some of these stress factors under control with a variety of programs. The cottage pollution control program was initiated in 1967 and was expanded in 1970 in order to solve the cottage waste disposal problem in recreational lakes. There are three ongoing studies carried out by the Ministry:

1. Evaluation of existing waste disposal systems and enforcement of repairs to those found to be unsatisfactory;
2. Research to improve the knowledge of septic tank operation and effects in shallow soil areas and evaluation of alternative

methods of private waste disposal;

3. Evaluation of present water quality in a number of recreational lakes. A totally undeveloped lake near Huntsville was studied in 1972 and 1973 in order to obtain more information about natural water quality conditions within a Precambrian Lake, which would assist in defining any unnatural conditions encountered in the developed lakes surveyed.

This report on Hazelwood Lake is one of a series dealing with the water quality aspects of the recreational lakes studied in 1973. As well as defining present status of water quality in the lakes, the data are meant to provide an historical reference for comparison of conditions at any future time.

SUMMARY

A study to evaluate the bacterial, chemical and biological water quality of Hazelwood Lake was carried out in the summer half of 1973.

Hazelwood Lake is a small lake, of moderate depth, located north of Thunder Bay in Gorham Township. Two shallow arms extend from the lake; a marshy one to the north receiving drainage from Surprise, Greenpike and Lottit Lakes; the other constricted by a causeway to form a downstream pond which drains to Ferguson Creek. Soils in the area are mainly shallow deposits of stony and bouldery sand till, with some areas of bare bedrock and of deep sand. While there are only four cottages on the lake, the Lakehead Conservation Authority plans to develop a major recreational area at the lake, and has presently developed a beach and camping area, and constructed an educational day centre on the east shore.

Hazelwood Lake had good bacteriological water quality in the June and August surveys and was within the Ministry of the Environment Microbiological Criteria for Recreational use. In August, although the upper portion of the narrow northwest bay (Station 5) exceeded the recreational criteria for both total coliforms and fecal streptococci, fecal coliforms remained low. Human contamination at this point was probably absent though some bacterial input of animal origin may have been present. This area was marshy and weedy and would not likely have been used for swimming.

The centre of the lake had better water quality than even the shore areas, which were not considered polluted. Intermittent high levels of total coliforms in an eastern bay might have been caused by recreational use at a nearby public beach.

Hazelwood Lake has very soft water, with a low mineral content

characteristic of lakes situated in hard rock areas. Low nutrient and chlorophyll _a_ levels indicate a little enrichment of the lake, but dissolved oxygen levels, depressed to 20% of saturation in the bottom waters in August accompanied by incipient signs of nutrient regeneration, suggest that the lake is in a borderline condition with respect to oxygen deficiency, and may be vulnerable to any increased nutrient inputs.

PURPOSE OF THE SURVEYS

As a result of human activity in the recreational lake environment, some wastes may reach the lake itself and this can lead to either or both of two major types of water quality impairment: microbial contamination, and excessive growths of algae and aquatic plants. While the two problems can result from a common source of pollution, the consequences of each are quite different.

Microbial contamination by raw or inadequately treated sewage does not significantly change the appearance of the water but poses an immediate public health hazard when the water is used for drinking or swimming. This type of pollution can be remedied by preventing wastes from reaching a lake. If this is the only source of pollution, satisfactory water quality will then return since disease causing bacteria do not usually persist in lake water.

Problems due to nutrient enrichment may be long lasting even if further excess nutrients are prevented from entering the lake. Nutrient enrichment, or eutrophication, results from the addition of plant fertilizers which occur naturally and which are also present in virtually all forms of raw or treated human wastes. High concentrations of these fertilizers (plant nutrients), mainly nitrogen and phosphorus, can support excessive growths of rooted aquatic plants and of microscopic free-floating plants called algae. While aquatic weed beds provide shelter, and both algae and rooted plants provide food for many kinds of fish, excessive growths of either are undesirable since they can upset the oxygen balance in the lake, interfere with recreational uses, and greatly affect the lake's appearance. They do not, however, generally pose a health hazard.

In order to detect either of these conditions, the surveys were designed, and tests selected, to evaluate the current condition of the lake with respect to:

- lakeshore development
- the distribution and abundance of bacteria
- changes in temperature, dissolved oxygen and water quality with depth
- plant nutrients and suspended algae
- densities and species of aquatic plants

DESIGN OF THE SURVEYS

Sampling Locations and Frequency

A proper estimate of the bacterial population requires several measurements of bacterial densities over a period of time which can then be averaged as a geometric mean. Measurements over five consecutive days at each station are regarded as the minimum number which, when taken at many lake stations, will give reliable bacteriological results.

Five day bacteriological, chemical and biological surveys were carried out from June 12 to 16 and from August 7 to 11. Additional chemical and biological samples were collected over a three day period from September 19 to 21.

Samples for bacterial analysis were taken daily one meter below the surface at 16 stations established throughout the lake, as well as from one meter above the bottom at each mid-lake station (Figure 2).

Chemical samples were taken through the illuminated layer of surface water and from one meter above bottom at each mid-lake station, but at the inlet stations, were collected one meter below the surface. During the five day spring and summer surveys, chemical samples were obtained on the first and

fifth day. Through the three day fall survey they were collected each day. Separate samples for chlorophyll analysis were collected daily through the illuminated surface water at the mid-lake and inlet stations.

Aquatic plant samples were obtained from areas representative of sparse, medium and dense growth.

Field Tests

The variations in temperature and dissolved oxygen values with depth were measured at the two deep water stations with an electronic probe lowered into the lake and water clarity was measured with a Secchi disc, (Figure 1). The pH of the samples was also measured in the field.

Bacteriological Tests

The numbers of bacteria in each of three types of "indicator" organisms were determined on each sample. The three bacterial types, total coliform, fecal coliform and enterococcus (fecal streptococcus) bacteria are all indigenous to man and other warm blooded animals, and are found in the colon and feces in tremendous numbers. Many diseases common to man can be transmitted by feces, consequently, the probability of occurrence of these diseases is usually highest in areas where the water is contaminated. These indicator organisms in water connote the possible presence of disease causing organisms.

The density (numbers per 100 ml) of the indicator bacteria in water will vary considerably between pairs of samples taken at the same situation, or at different stations on a lake, or if taken at different times, and so the assessment of water quality cannot be determined accurately from a single water sample[1]. Therefore the bacteriological surveys require many samples to be taken at several lake stations over a period of time, and following this the large amount of data so obtained is reduced by calculation to meaningful and easily manipulated statistics.

[1]Guidelines and Criteria for Water Quality Management in Ontario M.O.E. 1973.

The "Secchi Disc Reading" is obtained by averaging the depth at which a 23cm (9") dia. black and white plate, lowered into the lake just disappears from view and the depth where it reappears as it is pulled up.

Most of the free-floating algae are suspended in the illuminated region between the lake surface and 2 times the Secchi disc reading.

Clear, algae-free lake: Secchi disc readings tend to be greater than 3m (9 feet).

Turbid or algae-rich lake: Secchi disc readings tend to be less than 3m (9 feet).

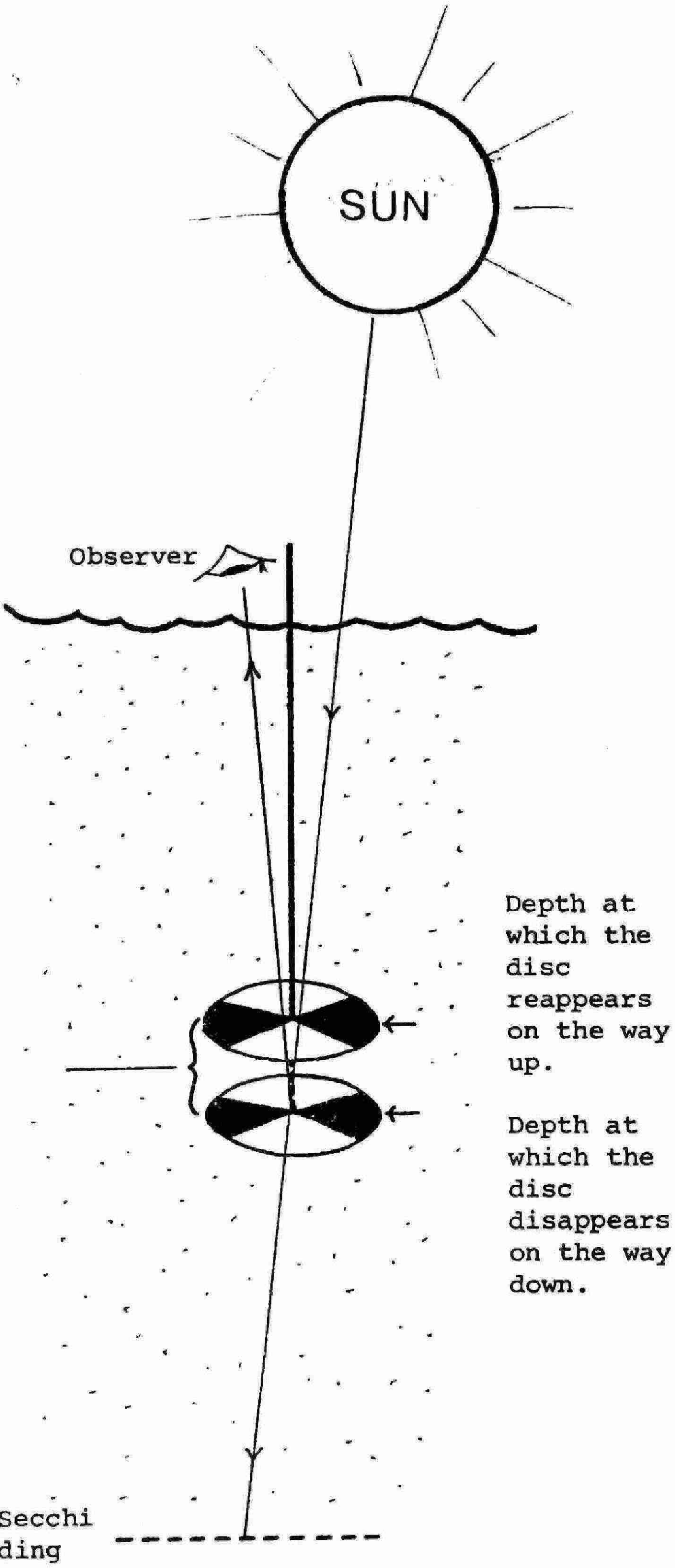


FIGURE I: USE OF SECCHI DISC TO DETERMINE WATER CLARITY

These data were then evaluated by statistical techniques in the following manner. The geometric mean,[1] (the most appropriate central value) and standard deviation were calculated for the values of each bacterial type at every station, providing concise valid data. Statistically significant variations in the bacterial densities between stations, or groups of stations, were determined by selected statistical techniques[2]. By these means the data from each station were tested against those of every other station until all stations with similar geometric mean densities were separated into groups (Group A, B---).

The group results, and those for individual stations, were then displayed on a map of the lake with each group identified by different stippling. Within each stippled area the group geometric mean applied for each type of bacteria, unless otherwise indicated by individual station values. The areas of better or worse bacterial quality were defined by the group geometric mean densities, and so any inputs of bacterial contamination, and the areas they affect, were readily identified.

Chemical Tests

Hardness, alkalinity, chloride, iron and conductivity were measured in order to define the mineral composition of the water. The types of plants and animals which thrive, effects of toxic materials and suitability of the lake for various management techniques are affected by the mineral content.

Total and soluble phosphorus were measured in the inlet and bottom water samples while total phosphorus only was measured in the mid-lake and outlet surface samples. Soluble phosphorus concentrations are used mainly to substantiate various interpretations of the total phosphorus concentrations.

[1]Guidelines and Criteria for Water Quality Management in Ontario MOE 1973.
[2]An Analysis of Variance and Bartlett's Test of Homogeneity.

The total Kjeldahl nitrogen is (apart from ammonia:nitrogen) essentially the amount of nitrogen contained in organic material. It was measured in all of the chemical samples. The soluble forms of nitrogen:ammonia, nitrite and nitrate, were measured in the inlet and bottom water samples. They are particularly important in bottom waters since nitrogen may be regenerated from decaying organic matter in these forms.

Chlorophyll _a_ concentrations are an indication of the amount of suspended algae in the water. The live algae are confined mainly to the illuminated surface waters which extend down to a depth of about twice the Secchi disc reading. The chlorophyll samples were collected by filling the sample bottle as it was lowered and raised through the depth of the illuminated surface waters. The sample was then representative of the algal density through the sampling depth.

DESCRIPTION OF HAZELWOOD LAKE AREA

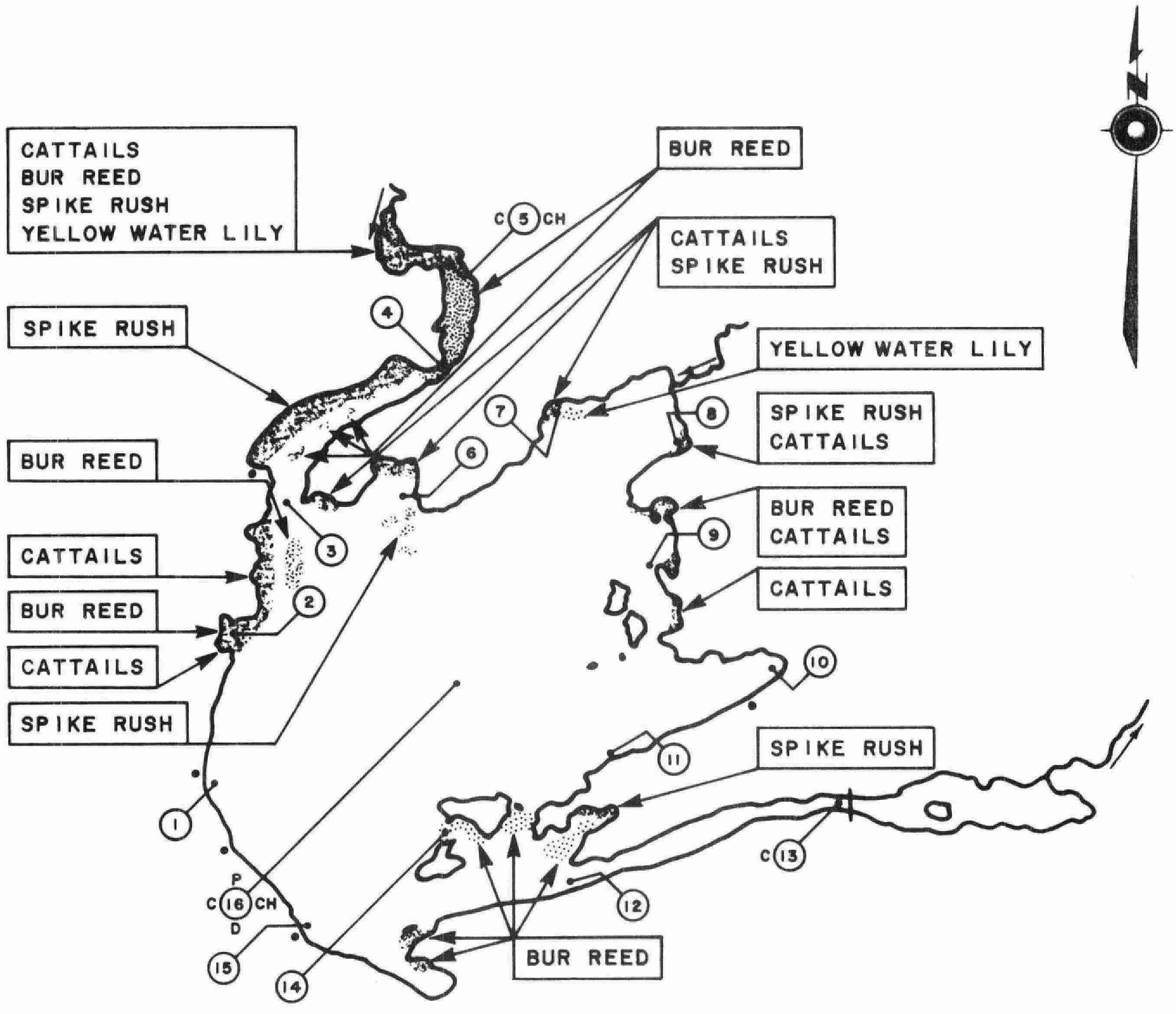
Lake and Soil Characteristics

Hazelwood Lake is located 21 kilometers (13 miles) north of Thunder Bay in Gorham Township. The lake is roughly rectangular in shape with two long narrow bays projecting from it; one from the northwest corner, the other from the southeast corner (Figure 2). The main body of the lake is approximately 1.5 kilometers (0.9 miles) long, and the same in width. The water surface area of 2.9 square kilometers (700 acres) is contained by 18 kilometers (11 miles) of shoreline. The lake consists of one basin, which has a maximum depth of 12.0 meters (40 feet) and a mean depth of 9 meters (30 feet).

Hazelwood Lake has an immediate drainage basin of 343 square kilometers (14,000 acres). The major inflow, which empties into the northern tip of the lake, includes drainage from Surprise, Greenpike and Lottit Lakes. The upper reach of the bay where this inflow enters is virtually a marsh, impassible except by canoe. There is a small watercourse draining into the northeast bay from Goodman Lake, but flow in it was negligible and no samples were taken at the mouth during this study. Drainage from Hazelwood Lake to Ferguson Creek is via the narrow bay projecting off the southeast corner of the lake. A causeway has been constructed across this bay, approximately 700 meters from the end, and flow past this point has been restricted to two large culverts which pass through the causeway. This has essentially created a separate pond out of the portion of the bay east of the causeway.

Hazelwood Lake lies within the Dog Lake Landscape Unit, (Ontario Land Inventory Classification), which is further divided into ten land units, three of which border the lake. The land unit encompassing the

FIGURE 2 - STATION LOCATIONS, LAKESHORE DEVELOPMENT AND MAJOR AREAS OF SHORELINE AQUATIC PLANT GROWTH OF HAZELWOOD LAKE



LEGEND

— COTTAGE DEVELOPMENT

— SAMPLING STATION
- C — CHEMICAL SAMPLE
- P — PROFILE
- CH — CHLOROPHYLL SAMPLE
- D — DEPTH STATION

WEEDED AREAS

— HEAVY GROWTH (75-100% BOTTOM COVERAGE)

— MODERATE GROWTH (50-75% BOTTOM COVERAGE)

— SCATTERED GROWTH (25-50% BOTTOM COVERAGE)

0 .5 1 KILOMETRES

0 1/4 1/2 MILES

ENVIRONMENT ONTARIO

RECREATIONAL LAKES PROGRAM

HAZELWOOD LAKE

1973 WATER QUALITY SURVEY

SCALE: AS SHOWN	
DRAWN BY: A.R.S.	DATE: JULY, 1974
CHECKED BY:	DRAWING Nº: 5045

greatest portion of the shoreline is composed primarily of shallow deposits of stony and bouldery, low alkalinity Hele fine sand till overlying resistant, low alkalinity Orient Bay bedrock. The remainder of the unit includes localized areas of bare bedrock, deep fine sand till and deep coarse sand valley train deposits.

Shoreline Development and Water Usage

Hazelwood Lake is under the jurisdiction of the Lakehead Conservation Authority, who have developed a beach and camping area on the east shore of the lake, and are presently constructing an educational day centre in the same locale. There are only four cottages on the lake, and most of the lake still exists in a wilderness state, with numerous beaver lodges in the sheltered bays. The lake receives very little traffic, with the exception of fishermen and weekend campers. The common game fish are northern pike and pickerel plus numerous coarse fish.

RESULTS AND DISCUSSION

Bacteriology

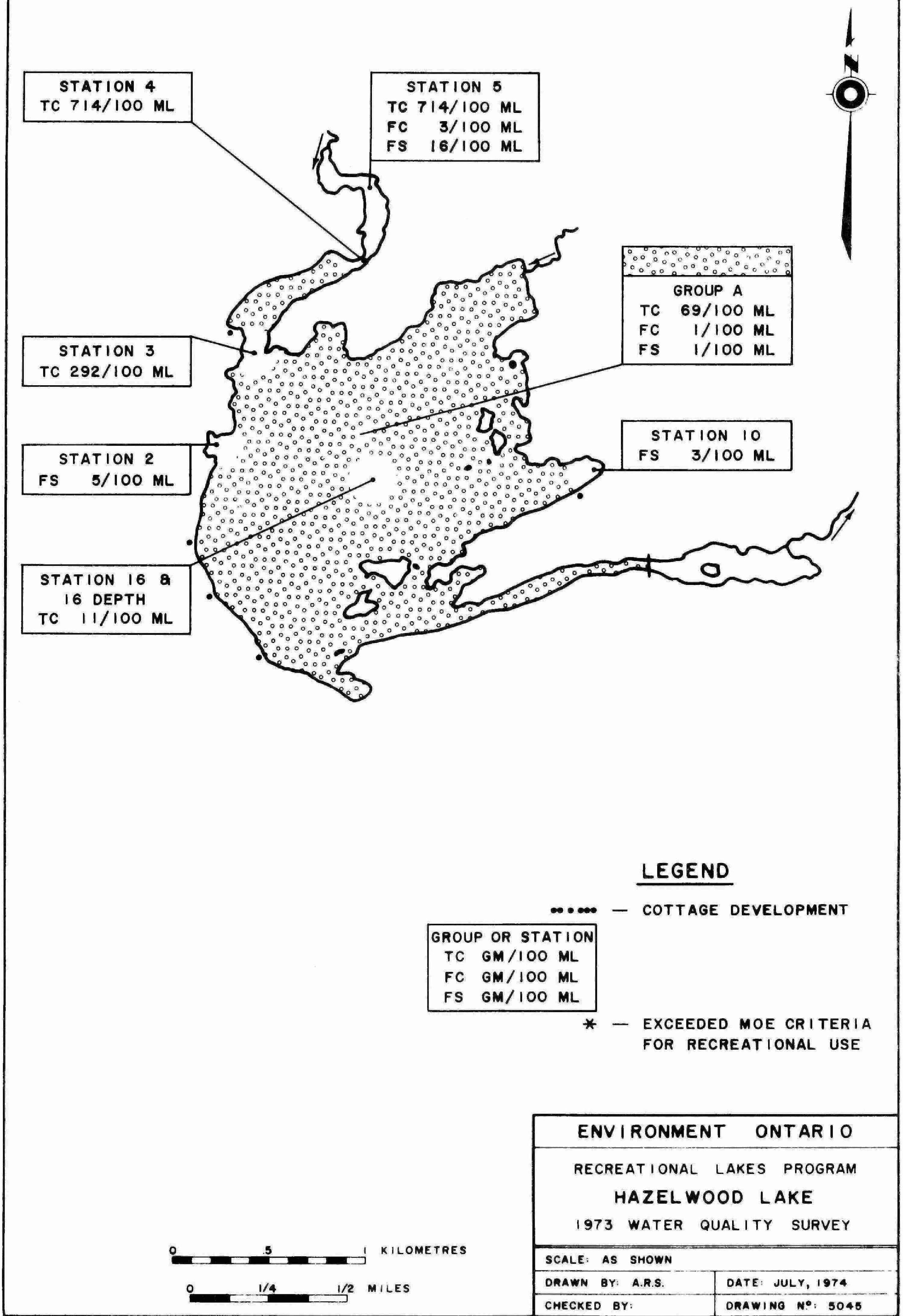
The June and August surveys showed that the water quality of Hazelwood Lake in 1973 was good and met the Ministry of the Environment Microbiological Criteria for Total Body Contact Recreational Use, which states:

> "Where ingestion is probable, recreational waters can be considered impaired when the coliform (TC), fecal coliform (FC) and/or enterococcus (fecal streptococcus, FS) geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively, in a series of at least ten samples per month, ----(1)".

In June the geometric mean densities for Hazelwood Lake were 69 TC, 1 FC and 1 FS per 100 ml (Group A; Figure 3) with the most important exception being the upper portion of the narrow northwest bay (Station 5) with higher bacterial densities of 714 TC, 3 FC, and 16 FS per 100 ml. This area was marshy and heavily populated with aquatic plants and birds which probably contributed to the high bacterial densities. Fecal coliform levels were low so human contamination at this point was probably absent. The two other stations (3, 4) in the lower portion of the narrow northwest bay also yielded higher bacterial densities than Group A, with values of 292 TC and 714 TC per 100 ml respectively. The water here supported many aquatic plants but less so than the upper portion of the bay. Two nearshore stations (2, 10) gave higher fecal streptococcus densities, 5 FS and 3 FS per 100 ml respectively, whereas the centre of the lake (stations 16, 16D) had total coliform geometric mean densities of 11 TC per 100 ml which indicated better water quality than that of the shore areas.

(1) Guidelines and Criteria for Water Quality Management in Ontario M.O.E. 1973.

FIGURE 3 - DISTRIBUTION OF BACTERIA FOR THE JUNE 12 TO JUNE 16 SURVEY



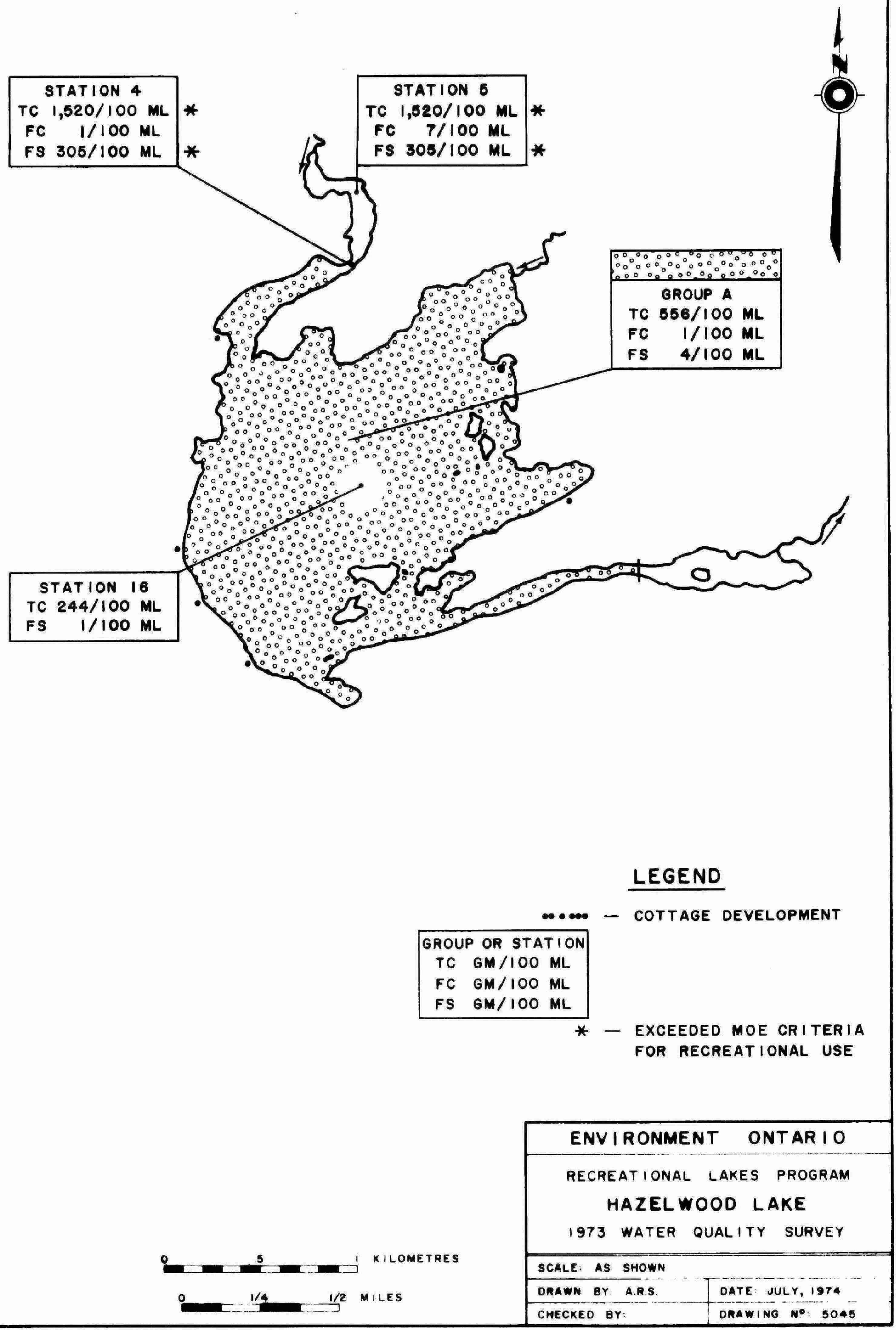
The August data indicated that for the main part of the lake the bacterial levels were 556 TC, 1 FC, and 4 FS per 100 ml (Group A; Figure 4). The upper portion of the narrow northwest bay again had different bacterial densities than most of the lake; the stations 4 and 5 mean densities were 1,520 TC, and 305 FS per 100 ml but the latter station also had fecal coliform levels of 7 FC per 100 ml. The high levels of total coliform and fecal streptococcus bacteria, which both exceeded the Recreational Criteria, probably rendered the bay unfit for swimming, though human contamination was not indicated. The bay would not likely be used for swimming due to the presence of large numbers of aquatic plants. The total coliform densities for a public beach area in an eastern bay (station 10) tended to be higher than other stations in group A.

The geometric mean densities of total coliform and fecal streptococci rose from values of 69 TC and 1 FS per 100 ml in June to 556 TC and 4 FS per 100 ml in August. The higher values were still within the Recreational Criteria. The summer values of fecal coliforms remained low, (1 FC per 100 ml). The values for the centre of the lake indicated better water quality than the shore areas in both surveys.

Chemistry

Hazelwood Lake is a very soft water lake with a mineral content lower than that of nearby Lake Superior. A slight increase in hardness, alkalinity and conductivity was noted over the period of the three surveys, identical in the lake and in the inflow and outflow. This was probably due to decreased rainfall and increased evaporation, which cause a greater proportion of groundwater percolation to the watercourses.

FIGURE 4 - DISTRIBUTION OF BACTERIA FOR THE AUG. 7 TO AUG. 11 SURVEY



	Range of Increase	Seasonal Average
Hardness as $CaCO_3$, mg/l	15 to 20	18
Alkalinity as $CaCO_3$, mg/l	11 to 14	13
Conductivity, micromhos/cm^3	36 to 41	39
Chloride as Cl, mg/l	-	less than 1
Sulphate as SO_4, mg/l	-	8
Sodium as Na, mg/l	-	2
Potassium as K, mg/l	-	1

Iron levels in the inflow (Station 5) were consistently high with an average of 0.8 mg/l, and reached a peak of 1.1 mg/l in August. This was not reflected in the upper waters of the lake or the outflow, which remained close to 0.3 mg/l, but was evident in the bottom waters which averaged 0.45 mg/l and peaked at 0.6 mg/l in August, suggesting that the iron input was settling to the bottom. A similar but less pronounced pattern was present in the total phosphorus levels, which averaged 13 µg/l, in the inflow and outflow, only 9 µg/l in the upper waters, and 16 µg/l in the bottom waters of Hazelwood Lake.

Total Kjeldahl nitrogen averages were also highest in the inflow, at 460 µg/l, and lowest in the surface waters of the lake, at 350 µg/l. An intermediate level was present at the bottom and in the outflow, 390 µg/l.

The soluble nutrients: nitrite, nitrate, and ammonia nitrogen; and soluble phosphorus, were generally low, at levels less than 10 µg/l. In August, nitrate appeared at levels of 85 µg/l in the bottom waters, accompanied by 24 µg/l of total phosphorus, and the elevated iron of 0.6 mg/l mentioned above, indicating that a slight degree of nutrient regeneration was occurring from the sediments. This was not sufficient to raise the levels in the upper waters upon mixing during the fall overturn.

As is usual for lakes of this depth in our climate, the bottom waters remained cool as the surface waters warmed through summer, forming a zone of rapid temperature decline (thermocline) (Figure 5). Since the waters below this level were thus cut off from access to additional oxygen, decomposition processes produced a cumulative oxygen deficit, carbon dioxide surplus and a lower pH. By June, dissolved oxygen had declined to 80% of saturation near the bottom, and in August only 20% remained one meter above the bottom, inducing the nutrient regeneration noted above. By September the lake had mixed thoroughly, becoming uniform in temperature and oxygen from top to bottom, probably correcting the oxygen deficiency and its related problems for the ensuing winter (see page A-6).

Hazelwood Lake would thus appear to be in a borderline condition with respect to oxygen deficiencies and be vulnerable to any increased nutrient inputs. The reduced August levels of dissolved oxygen at the bottom have probably been a factor in the absence of cold water game fish species, which do not thrive at such low levels.

Chlorophyll *a* and Water Clarity

As would be expected from the low phosphorus levels, the chlorophyll results for Hazelwood Lake indicated low quantities of suspended algae in the illuminated zone of the surface waters. At the mid-lake station, chlorophyll *a* concentrations ranged from 0.7 to 3.2 μg/l, and averaged 1.8 over the three surveys. Water clarity, as measured by the Secchi disc, had a mean value of 2.8 meters. A curve relating chlorophyll *a* and Secchi disc values for a large number of Ontario lakes was derived by Ministry staff, and illustrates the status of Hazelwood Lake relative to other well-known Ontario lakes (Figure 6). The position of Hazelwood Lake diverges slightly from the curve, as do other local lakes, due to the natural brown colouration present in the water, which reduces the apparent clarity in addition to the reduction caused by suspended

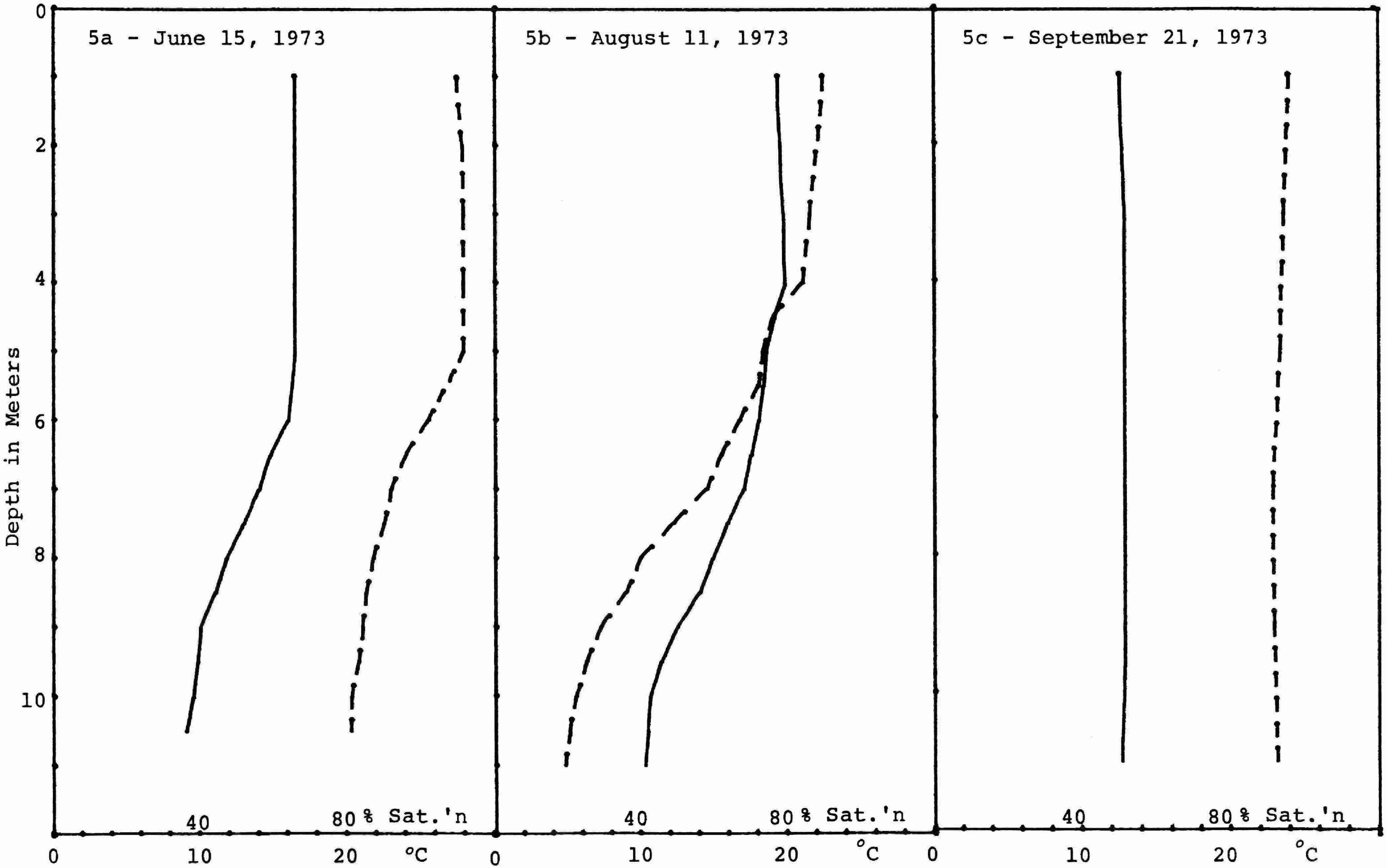


Figure 5 - Dissolved Oxygen (----) and Temperature (——) Profiles
at Station 16, Hazelwood Lake

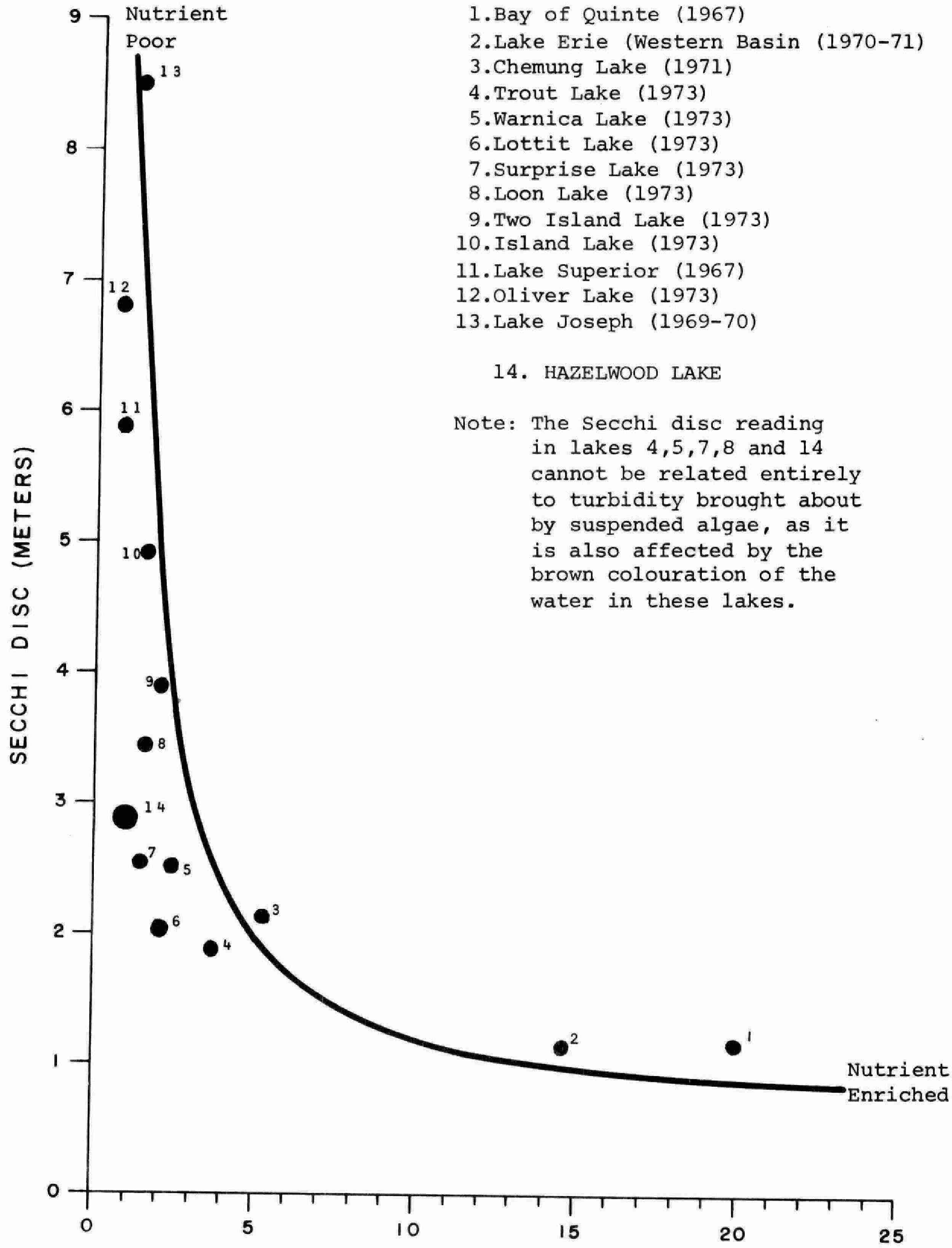


Figure 6: The mean chlorophyll a and Secchi disc measurements in Hazelwood Lake relative to many Ontario Lakes. Thirteen other lakes are included for comparison with Hazelwood Lake.

algae.

Presently, nutrient and chlorophyll a values indicate a low degree of enrichment in Hazelwood Lake. Lakes exhibit their symptoms of enrichment in several ways (see p. A-6 for an explanation of the relationships among nutrient enrichment, water clarity and abundance of suspended algae). Cottagers and camp operators can help to maintain the unenriched state (clear water and low algae density) of their lake by ensuring that seepage of nutrients to the lake from waste treatment and disposal facilities does not occur.

Aquatic Plants

With the exception of a heavily overgrown area at the inflow to the northern bay, aquatic plant growth in Hazelwood Lake (of the species listed below) was relatively sparse and confined to small, sheltered areas of the shoreline (Figure 2). Most of the plants in the lake were of the emergent type (of upright growth; extending above the surface of the water) and therefore particularly well suited to waterfowl habitat. The absence of those species of plants commonly known as "weedy" or troublesome, such as milfoil, coontail and Canada waterweed, is noteworthy.

Scientific Name	Common Name
Eleocharis sp.	spike rush
Sparganium sp.	burreed
Nuphar variegatum	yellow waterlily
Typha latifolia	cattail

INFORMATION OF GENERAL INTEREST TO COTTAGERS

MICROBIOLOGY OF WATER

For the sake of simplicity, the micro-organisms in water can be divided into two groups: the bacteria that thrive in the lake environment and make up the natural bacterial flora; and the disease causing micro-organisms, called pathogens, that have acquired the capacity to infect human tissues.

The "pathogens" are generally introduced to the aquatic environment by raw or inadequately treated sewage, although a few are found naturally in the soil. The presence of these bacteria does not change the appearance of the water but poses an immediate public health hazard if the water is used for drinking or swimming. The health hazard does not necessarily mean that the water user will contract serious waterborn infections such as typhoid fever, polio or hepatitis, but he may catch less serious infections of gastro-enteritis (sometimes called stomach flu), dysentery or diarrhea. Included in these minor afflictions are eye, ear and throat infections that swimmers encounter every year and the more insidious but seldom diagnosed, sub-clinical infections usually associated with several waterborn viruses. These viral infections leave a person not feeling well enough to enjoy holidaying although not bedridden. This type of microbial pollution can be remedied by preventing wastes from reaching the lake and water quality will return to satisfactory conditions within a relatively short time (approximately one year) since disease causing bacteria usually do not thrive in an aquatic environment.

The rest of the bacteria live and thrive within the lake environment. These organisms are the instruments of biodegradation. Any organic matter in the lake will be used as food by these organisms and will give rise, in turn to subsequent increases in their numbers. Natural organic matter as well as that from sewage, kitchen wastes, oil and gasoline are readily attacked by these lake bacteria. Unfortunately, biodegradation of the organic wastes by organisms uses correspondingly large amounts of the dissolved oxygen. If the organic matter content of the lake gets high enough, these bacteria will deplete the dissolved oxygen supply in the bottom waters and threaten the survival of many deep-water fish species.

RAINFALL AND BACTERIA

The "Rainfall Effect" referred to in the text, relates to a phenomenon that has been documented in previous surveys of the Recreational Lakes. Heavy precipitation has been shown to flush the land area around the lake and the subsequent runoff will carry available contaminants including sewage organisms as well as natural soil bacteria with it into the water.

Total coliforms, fecal coliforms and fecal streptococci, as well as other bacteria and viruses which inhabit human waste disposal systems, can be washed into the lake. In Precambrian areas where there is inadequate soil cover and in

fractured limestone areas where fissures in the rocks provide access to the lake, this phenomenon is particularly evident.

Melting snow provides the same transportation function for bacteria, especially in an agricultural area where manure spreading is carried out in the winter on top of the snow.

Previous data from sampling points situated 50 to 100 feet from shore indicate that contamination from shore generally shows up within 12 to 48 hours after a heavy rainfall.

WATER TREATMENT

Lake and river water is open to contamination by man, animals and birds (all of which can be carriers of disease); consequently, NO SURFACE WATER MAY BE CONSIDERED SAFE FOR HUMAN CONSUMPTION without prior treatment, including disinfection. Disinfection is especially critical if coliforms have been shown to be present.

Disinfection can be achieved by:

(a) Boiling

Boil the water for a minimum of five minutes to destroy the disease causing organisms.

(b) Chlorination using a household bleach containing 4 to 5¼ percent available chlorine.

Eight drops of a household bleach solution should be mixed with one gallon of water and allowed to stand for 15 minutes before drinking.

(c) Continuous Chlorination

For continuous water disinfection, a small domestic hypochlorinator (sometimes coupled with activated charcoal filters) can be obtained from a local plumber or water equipment supplier.

(d) Well Water Treatment

Well water can be disinfected using a household bleach (assuming strength at 5 percent available chlorine) if the depth of water and diameter of the well are known.

CHLORINE BLEACH
Per 10 ft. Depth of Water

Diameter of Well Casing in Inches	One to Ten Coliforms	More Than Ten Coliforms
4	0.5 oz.	1 oz.
6	1 oz.	2 oz.
8	2 oz.	4 oz.
12	4 oz.	8 oz.
16	7 oz.	14 oz.
20	11 oz.	22 oz.
24	16 oz.	31 oz.
30	25 oz.	49 oz.
36	35 oz.	70 oz.

Allow about six hours of contact time before using the water.

Another bacteriological sample should be taken after one week of use.

Water Sources (spring, lake, well, etc.) should be inspected for possible contamination routes (surface soil, runoff following rain and seepage from domestic waste disposal sites). Attempts at disinfecting the water alone without removing the source of contamination will not supply bacteriologically safe water on a continuing basis.

There are several types of low cost filters (ceramic, paper, carbon, diatomaceous earth sometimes impregnated with silver, etc.) that can be easily installed on taps or in water lines. These may be useful to remove particles, if water is periodically turbid, and are usually very successful. Filters, however, do not disinfect water but may reduce bacterial numbers. For safety, chlorination of filtered water is recommended.

SEPTIC TANK INSTALLATIONS

In Ontario, provincial law requires under Part 7 of the Environment Protection Act that before you extend, alter, enlarge or establish any building where a sewage system will be used, a Certificate of Approval must be obtained from the Ministry of the Environment or its representatives. The local municipality or Health Unit may be delegated the authority to issue the Certificate of Approval. Any other pertinent information such as size, types and location of septic tanks and tile fields can also be obtained from the same authority.

(1) General Guidelines

A septic tank should not be closer than:

-50 feet to any well, lake, stream, pond, spring, river or reservoir

-5 feet to any building
-10 feet to any property boundary

The tile field should not be closer than:

-100 feet to the nearest dug well
-50 feet to a drilled well which has a casing to 25 feet below ground
-25 feet to a building with a basement that has a floor below the level of the tile in the tile bed
-10 feet to any other building
-10 feet to a property boundary
-50 feet to any lake, stream, pond, spring, river or reservoir

The ideal location for a tile field is in a well-drained, sandy loam soil remote from any wells or other drinking water sources. For the tile field to work satisfactorily, there should be at least 3 feet of soil between the bottom of the weeping tile trenches and the top of the groundwater table or bedrock.

Recognizing that private sewage systems are relatively inefficient where shallow and inappropriate soil conditions are present (e.g. Precambrian areas) the Ministry of the Environment is conducting research into alternate methods of private sewage disposal in unsewered areas; into the improvement of existing equipment and methods of design and operation for these systems; and into the development of better surveillance methods such as by the use of chemical, biological and radioactive tracers to detect the movement of pollutants through the soil mantle.

DYE TESTING OF SEPTIC TANK SYSTEMS

There is considerable interest among cottage owners to dye test their sewage systems; however, several problems are associated with dye testing. Dye would not be visible to the eye from a system that has a fairly direct connection to the lake. Thus, if a cottager dye-tested his system and no dye was visible in the lake, he would assume that his system is satisfactory, which might not be the case. A low concentration of dye is not visible and therefore expensive equipment such as a fluorometer is required. Only qualified people with adequate equipment are capable of assessing a sewage system by using dye. In any case, it is likely that some of the water from a septic tank will eventually reach the lake. The important question is whether all contaminants including nutrients have been removed before it reaches the lake. To answer this question special knowledge of the system, soil depth and composition, underground geology of the region and the shape and flow of the shifting water table are required. Therefore, we recommend that this type of study should be performed only by qualified professionals.

BOATING AND MARINA REGULATIONS

In order to help protect the lakes and rivers of Ontario from pollution, it is required by law that sewage (including garbage) from all pleasure craft, including houseboats, must be retained in suitable equipment. Equipment which is considered suitable by the Ministry of the Environment includes (1) retention devices with or without re-circulation which retain all toilet wastes for disposal ashore, and (2) incinerating devices which reduce all sewage to ash.

Equipment for storage of toilet wastes shall:

1. be non-portable
2. be constructed of structurally sound material
3. have adequate capacity for expected use
4. be properly installed, and
5. be equipped with the necessary pipes and fittings conveniently located for pump-out by shore-based facilities (although not specified, a pump-out deck fitting with 1½-inch diameter National Pipe Thread is commonly used).

An Ontario regulation requires that marinas and yacht clubs provide or arrange pump-out service for the customers and members who have toilet-equipped boats. In addition, all marinas and yacht clubs must provide litter containers that can be conveniently used by occupants of pleasure boats.

The following "Tips" may be of assistance to you in boating:

1. Motors should be in good mechanical condition and properly tuned.
2. When a tank for outboard motor testing is used, the contents should not be emptied into the water.
3. If the bilge is cleaned, the waste material must not be dumped into the water.
4. Fuel tanks must not be overfilled and space must be left for expansion if the fuel warms up.
5. Vent pipes should not be obstructed and fuel needs to be dispensed at a correct rate to prevent "blow-back".
6. Empty oil cans must be deposited in a leak-proof receptable, and,
7. Slow down and save fuel.

EUTROPHICATION OR EXCESSIVE FERTILIZATION AND LAKE PROCESSES

In recent years, cottagers have become aware of the problems associated with nutrient enrichment of recreational lakes and have learned to recognize many of the symptoms characterizing nutrient enriched (eutrophic) lakes. It is important to realize that small to moderate amounts of aquatic plants and algae are necessary to maintain a balanced aquatic environment. They provide food and a suitable environment for the growth of aquatic invertebrate organisms which serve as food for fish. Shade from large aquatic plants helps to keep the lower water cool, which is essential to certain species of fish and also provides protection for young game and forage fish. Numerous aquatic plants are utilized for food and/or protection by many species of waterfowl. However, too much growth creates an imbalance in the natural plant and animal community particularly with respect to oxygen conditions, and some desirable forms of life such as sport fish are eliminated and unsightly algae scums can form. The lake will not be "dead" but rather abound with life which unfortunately is not considered aesthetically pleasing. This change to poor water quality becomes apparent after a period of years during which extra nutrients are added to the lake and return to the natural state may also take a number of years after the nutrient inputs are stopped.

Changes in water quality with depth are a very important characteristic of the lake. Water temperatures are uniform throughout the lake in the early spring and winds generally keep the entire volume well mixed. Shallow lakes may remain well mixed all summer so that water quality will be the same throughout. On the other hand, in deep lakes, the surface waters warm up during late spring and early summer and float on the cooler more dense water below. The difference in density offers a resistance to mixing by wind action and many lakes do not become fully mixed again until the surface waters cool down in the fall. The bottom water receives no oxygen from the atmosphere during this unmixed period and the dissolved oxygen supply may be all used up by bacteria as they decompose organic matter. Cold water fish, such as trout, will have to move to the warm surface waters to get oxygen and because of the high water temperatures they will not thrive, so that the species will probably die out (see Figure next page).

Low oxygen conditions in the bottom waters are not necessarily an indication of pollution but excessive aquatic plant and algae growth and subsequent decomposition in the bottom waters can aggravate the condition and in some cases result in zero oxygen levels in lakes which had previously held some oxygen in the bottom waters all summer. Although plant nutrients normally accumulate in the bottom waters of the lakes, they do so to a much greater extent if there is no oxygen present. These nutrients become available for algae in the surface waters when the lake mixes in the fall and dense algae growths can result.

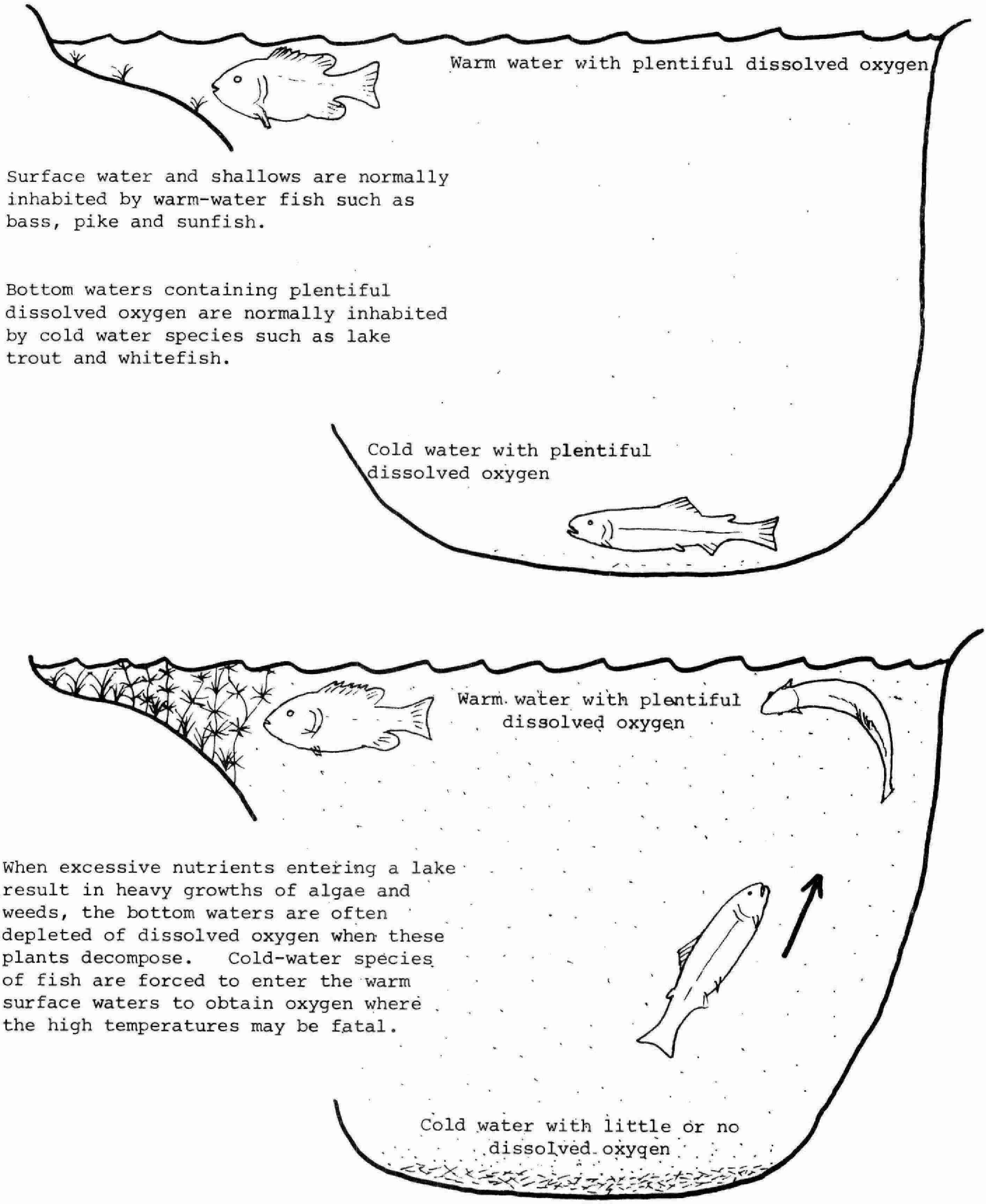


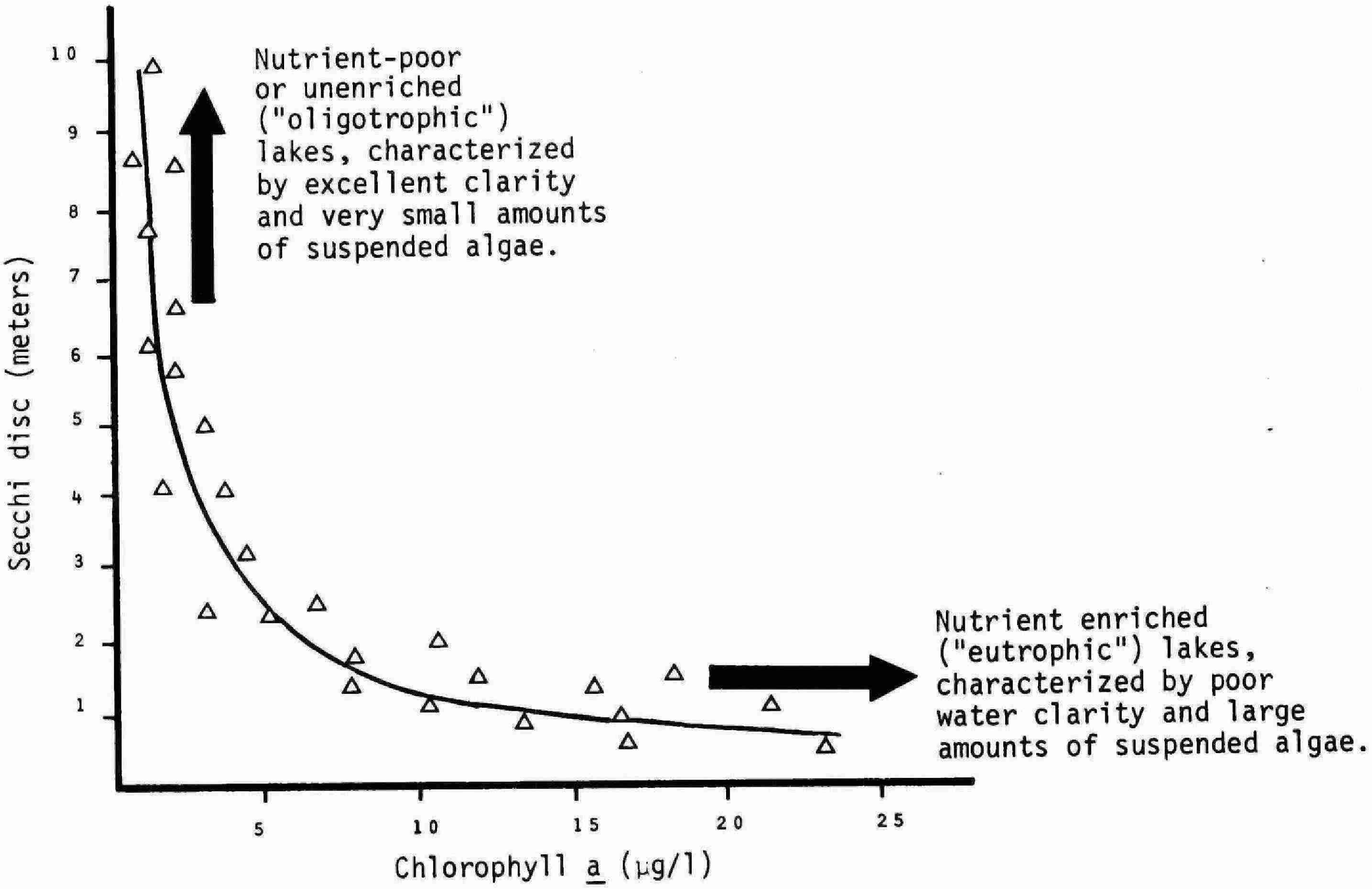
FIGURE A-1: DECOMPOSITION OF PLANT MATTER AT THE LAKE BOTTOM CAN LEAD TO DEATH OF DEEP-WATER FISH SPECIES.

Consequently, lakes which have no oxygen in the bottom water during the summer are more prone to having algae problems and are more vulnerable to nutrient inputs than lakes which retain some oxygen.

Like humans, aquatic plants and algae require a balanced "diet" for growth. Other special requirements including those for light and temperature are specific for certain algae and plants. Chemical elements such as nitrogen, phosphorus, carbon, and several others are required and must be in forms which are available for uptake by plants and algae. Growth of algae can be limited by a scarcity of any single "critical" nutrient. Nitrogen and phosphorus are usually considered "critical" nutrients because they are most often in scarce supply in natural waters, particularly in lakes in the Precambrian area of the province. Phosphorus, especially is necessary for the processes of photosynthesis and cell division. Nitrogen and phosphorus are generally required in the nitrate-N (or ammonia-N) and phosphate forms and are present in natural land runoff and precipitation. Human and livestock wastes are a very significant source of these and other nutrients for lakes in urban and agricultural areas. It is extremely important that cottage waste disposal systems function so that seepage of nutrients to the lake does not occur since the changes in water quality brought about by excessive inputs of nutrients to lakes are usually evidenced by excessive growths of algae and aquatic plants.

The large amounts of suspended algae which materialize from excessive inputs of nutrients, result in turbid water of poor clarity or transparency. On the other hand, lakes with only small, natural inputs of nutrients and correspondingly low nutrient concentrations (characteristically large and deep lakes) most often support very small amounts of suspended algae and consequently, are clear-water lakes. An indication of the degree of enrichment of lakes can therefore be gained by measuring the density of suspended algae (as indicated by the chlorophyll a concentration - the green pigment in most plants and algae) and water clarity (measured with a Secchi disc). In this regard, staff of the Ministry of the Environment have been collecting chlorophyll a and water clarity data from several lakes in Ontario and have developed a graphical relationship between these parameters which is being used by cottagers to further their understanding of the processes and consequences of nutrient enrichment of Precambrian lakes. The figure on the next page illustrates the above-mentioned relationship.

In the absence of excessive coloured matter (eg. drainage from marshlands), lakes which are very low in nutrients are generally characterized by small amounts of suspended algae (i.e. chlorophyll a) and are clear-water lakes with high Secchi disc values. Such lakes, with chlorophyll a and Secchi disc values lying in the upper left-hand area of the graph are unenriched or nutrient poor ("oligotrophic") in status and do not suffer from the problems associated with excessive inputs of nutrients. In contrast, lakes with high chlorophyll a concentrations and poor clarity are positioned in the lower right-hand area of the graph and are enriched ("eutrophic"). These lakes usually exhibit symptoms of excessive nutrient enrichment including water turbidity owing to large amounts of suspended algae which may float to the surface and accumulate in sheltered areas around docks and bays.



Measurements of suspended algal density (chlorophyll a) and water clarity are especially valuable if carried out over several years. Year to year positional changes on the graph can then be assessed to determine whether or not changes in lake water quality are materializing so that remedial measures can be implemented before conditions become critical.

CONTROL OF AQUATIC PLANTS AND ALGAE

Usually aquatic weed growths are heaviest in shallow shoreline areas where adequate light and nutrient conditions prevail.

Extensive aquatic plant and algal growths sometimes interfere with boating and swimming and ultimately diminish shoreline property values.

Control of aquatic plants may be achieved by either chemical or mechanical means. Chemical methods of control are currently the most practical, considering the ease with which they are applied. However, the herbicides and algicides currently available generally provide control for only a single season. It is important to ensure that an algicide or herbicide which kills the plants causing the nuisance, does not affect fish or other aquatic plants. Chemical control in the province is regulated by the Ministry of the Environment and a permit must be granted prior to any operation. Simple raking and chain dragging operations to control submergent species have been successfully employed in a number of situations; however, the plants soon re-establish themselves. Removal of weeds by underwater mowing techniques is certainly the most attractive method of control and is currently being evaluated in Chemung Lake near Peterborough. Guidelines and summaries of control methods, and applications for permits are available from the Pesticides Control Section, Pollution Control Branch, Ministry of the Environment, 135 St. Clair Avenue West, Toronto, Ontario M4V 1P5.

PHOSPHORUS AND DETERGENTS

Scientists have recognized that phosphorus is the key nutrient in stimulating algal growth in lakes and streams.

In past years, approximately 50 percent of the phosphorus contributed by municipal sewage was added by detergents. Federal regulations reduced the phosphate content (as P_2O_5) in laundry detergents from approximately 50 percent to 20 percent on August 1, 1970 and to 5 percent on January 1, 1973.

It should be recognized that automatic dishwashing compounds were not subject to the government regulations and that surprisingly high numbers of automatic dishwashers are present in resort areas (a questionnaire indicated that about 30 percent of the cottages in the Muskoka lakes have automatic dishwashers). Cottagers utilizing such conveniences may be contributing significant amounts of phosphorus to recreational lakes because automatic dishwashing compounds are characteristically high in phosphorus. Indeed, in most of Ontario's vacation land, the source of domestic water is soft enough to allow the exclusive use of liquid dishwashing compounds, soap and soap-flakes which are, in general, relatively low in phosphorus.

ONTARIO'S PHOSPHORUS REMOVAL PROGRAMME

By 1975, the Government of Ontario expects to have controls in operation at more than 200 municipal wastewater treatment plants across the province serving some 4.7 million persons. This represents about 90 percent of the population serviced by sewers. The programme is in response to the International Joint Commission recommendations as embodied in the Great Lakes Water Quality Agreement and studies carried out by the Ministry of the Environment on inland recreational waters which showed phosphorus to be a major factor influencing eutrophication. Specifically, the programme makes provision for nutrient control in the Upper and Lower Great Lakes, the Ottawa River system and in prime recreational waters where the need is demonstrated or where emphasis is placed upon prevention of localized, accelerated eutrophication.

Phosphorus removal facilities became operational at wastewater treatment plants on December 31, 1973, in the most critically affected areas of the province, including all the plants in the Lake Erie drainage basin and the inland recreational areas. The operational date for plants discharging to waters deemed to be in less critical condition, which includes plants larger than one million gallons per day (1 mgd) discharging to Lake Ontario and to the Ottawa River system, is December 31, 1975. The 1973 phase of the programme involved 113 plants, of which 48 are in prime recreational areas. An additional 53 new plants, each with phosphorus removal, are now under development, 23 of which are located in recreational areas. The capacities of these plants range from 0.04 to 24.0 mgd, serving an estimated population of 1,600,000 persons.

The 1975 phase will bring into operation another 54 plants ranging in size from 0.3 to 180 mgd serving an additional 3,100,00 persons. Treatment facilities utilizing the Lower Great Lakes must meet effluent guidelines of less than 1.0 milligram per litre of total phosphorus in their final effluent. Facilities utilizing the Upper Great Lakes, the Ottawa River Basin and certain areas of Georgian Bay where needs have been demonstrated must remove at least 80 percent of the phosphorus reaching their sewage treatment plants.

CONTROL OF BITING INSECTS

Mosquitoes and blackflies often interfere with the enjoyment of recreational facilities at the lake-side vacation property. Pesticidal spraying or fogging in the vicinity of cottages produces extremely temporary benefits and usually do not justify the hazard involved in contaminating the nearby water. Eradication of biting fly populations is not possible under any circumstances and significant control is rarely achieved in the absence of large-scale abatement programs involving substantial funds and trained personnel. Limited use of approved larvicides in small areas of swamp or in rain pools close to residences on private property may be undertaken by individual landowners, but permits are necessary wherever treated waters may contaminate adjacent streams or lakes. The use of repellents and light traps is encouraged as are attempts to reduce mosquito larval habitat by improving land drainage. Applications for permits to apply insecticides as well as technical advice can be obtained from the Ministry of the Environment, Pesticides Control Service, 3rd Floor, 1 St. Clair Avenue West, Toronto, Ontario.